experiments with photographic colour-filters would furnish no definite evidence either for or against the cosmical absorption or scattering of the violet rays.

In the same journal Mr. Paul R. Heyl also discusses the question of the apparent dispersion in space, and, whilst preferring Nordmann's monochromatic-photometry method, suggests that too great an importance has been attached to the parallax values used in measuring the dispersion; this would possibly account for the considerable differences between the values obtained by Tikhoff and Nordmann. Mr. Heyl also indicates that the objections urged by M. Lebedew against the methods are not unanswerable.

PLANETS AND THEIR SATELLITES.—In a note appearing in No. 4351 of the *Astronomische Nachrichten* (p. 97, August 27), Prof. Lowell shows that throughout the solar system there exists a remarkable parallelism between the ratios obtained by comparing the speeds of the satellites, about their primaries, with the velocities of the latter in their own orbits. A table showing the ratios for the systems of Jupiter, Saturn, Uranus, and Neptune displays relations which are too systematic to be merely fortuitous. In a brief discussion as to the effect of the calculated speeds, during the time the systems were evolving, in determining the relations between the satellites and the interplanetary particles through which they were passing, Prof. Lowell shows that the total effect of the particles on the large satellites was to retard the latter and cause them to approach the primaries. For retrograde satellites the effect was greater than for the direct, which may account for the preservation of the latter. Incidentally, this is shown to be antagonistic to the planetesimal hypothesis, wherein it is reasoned that the impact of the interplanetary particles on a direct satellite would accelerate it and thus prevent it being drawn down on to the planet; this is exactly contrary to the fact with any of the major satellites.

METEOR OBSERVATIONS.—As in previous years, organised observations of the Perseids were carried out by the members of the Belgian Astronomical Society at seven different stations, and the results are briefly reported in No. 21 of the *Gazette astronomique*. Each observing party kept watch from 10h. to 14h., each night, from August 7 to August 15, and the detailed discussion of the collected observations should provide some very useful information concerning this important shower. At Antwerp two observers recorded 492 meteors, 129 of which were of the first magnitude, or brighter, and the maximum display, both there and at Uccle, appears to have taken place on August 11; the horary numbers were 51·4 and 44·2 respectively.

Observations of the Perseids in 1908, and the Lyrids in 1909, were made at the Kasan Observatory, and the results are published in detail in No. 4350 of the *Astronomische Nachrichten*. Altogether, the paths of 132 Perseids and 59 Lyrids, with notes on their appearances and the values determined for the radiants, are given.

NEW SPECTROSCOPIC BINARIES.—No. 19, vol. i., of the Publications of the Allegheny Observatory contains the preliminary announcement that spectrograms taken with the Mellon spectrograph show the following five stars to be spectroscopic binaries:—(1) 30 H. Ursæ Majoris; range of 100 km. and period of 11·6 days. (2) B.D. + 3·2867°; 134 km. range and short period. (3) B.D. + 6·2875°; range of 80 km. (4) 25 Serpentis; range of 90 km. and a short period. (5) ι Coronæ; range 40 km., period short.

OBSERVATIONS OF PERRINE'S COMET.—Photographic observations of Perrine's comet, 1909*b*, were made at Greenwich on August 14 and 16, and at the Königstuhl Observatory on August 12, 15, and 19; on the latter date the magnitude was 15·0.

These observations show that, between the extreme dates, the ephemeris published by Prof. Kobold was nearly correct, the corrections in R.A. varying from +5s. on August 12 to −6s. on August 19; those for declination increased from −10·8′ to −14′ (*Astronomische Nachrichten*, No. 4350, p. 96).

THE BRITISH ASSOCIATION AT WINNIPEG.

SECTION D.

ZOOLOGY.

OPENING ADDRESS BY A. E. SHIPLEY, M.A.CANTAB., HON. D.SC.PRINCETON, F.R.S., PRESIDENT OF THE SECTION.

I.

Charles Darwin.

THIS is the year of centenaries. Perhaps in no other year in history were so many men born destined to impress their genius on the literature, the politics, and the science of the world as in 1809. The number of literary men who first saw the light in that *annus mirabilis* is almost too long to mention—Mark Lemon, the genial editor and one of the founders of *Punch*; "Crimean" Kinglake; John Stuart Blackie, until lately a well-known figure in Edinburgh; Monckton Milnes, the first Lord Houghton, "poet, critic, legislator, the friend of authors" and the father of Lord Crewe, who at present presides over that most important of all Government offices—that of the Colonies. One could prolong the list; and one must at least mention the names of Louis Braille, the inventor of the Braille type for the blind, of Fanny Kemble and of Elizabeth Barrett Browning, before passing on to remind you that this year is also the centenary of Tennyson, who, with Browning, formed the twin stars of poetry during the reign of Queen Victoria, and who from his intimate knowledge of natural history and his keen power of observation was essentially the poet of Darwinism. Of his life-long friend, born the same year, Edward Fitzgerald, the translator—one feels almost inclined to say author—of Omar Khayyám, and of the gifted musician Mendelssohn there is no time to speak.

On this side of the Atlantic, and yet not wholly on this side, for he spent five impressionable school years at Stoke Newington, we have that "fantastic and romantic" genius Edgar Allan Poe.[1] Later he studied at West Point, where surely he must have been as incongruous a student as James Whistler himself. We have also that kindly, humorous physician Oliver Wendell Holmes, a nature "sloping towards the southern side" as Lowell has it. Amongst many recollections of literary men I cherish none more dearly than that I once entertained him in my Cambridge and once visited him in his.

Three other names stand out. William Ewart Gladstone, that leader of men, a politician and a statesman capable more than most men at once of arousing the warmest affection of his followers and the bitterest hatred of those who went the other way. Cultured as he was and widely read, he had his limitations, and although his tenacious memory was stored with the humanities of all the ages, he was singularly devoid of any knowledge of science. If we may paraphrase the words of Lord Morley in his estimate of Gladstone's writings, we would say that his place is not in science, "nor in critical history, but elsewhere."

Abraham Lincoln, the greatest man born on this continent since the War of Independence, was some ten months older than Gladstone. Both men were great statesmen, both men were liberators; for we must not forget that in many minds the help Gladstone gave to Italy in her struggle for freedom and union remains the most enduring thing he achieved.

Yet in externals how different! One the finished, cultured product of the most aristocratic of our public schools and the most ancient of our universities, the other little read in the classics or in mediæval and ecclesiastical lore, yet deeply versed in the knowledge of men and how to sway them. Rugged, a little rough if you like, humorous and yet sad, eminently capable, a strong man, and at heart "a very perfect gentleman."

On the same day, February 12, upon which Lincoln first saw the light, was born at the "Mount," Shrewsbury, a little child destined as he grew up to alter our conceptions of organic life perhaps more profoundly than any other man has ever altered them, and this, not only in the subjects he made his own, but in every department of human knowledge and thought.

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[1] Poe lived from his eighth to his thirteenth year at the "Manor House School," Stoke Newington, at that time a village, now swallowed up by the metropolis. Poe described the place as he knew it, and his schoolmaster, Dr. Bransby, in "William Wilson."

Being as I am a member of Charles Darwin's own college, coming as I do straight from the celebration in which the whole world united to do his memory honour, it would seem meet that I should in this year of the centenary of his birth devote this address to a consideration of his life and of his work, and of such confirmation and modification of his theories as the work of the last fifty years has revealed.

As to the man, I can but quote two estimates of his character, one by a college companion who lived on terms of close intimacy with Darwin when at Christ's, the other the considered judgment of one who knew and loved and fought for Darwin in later life.

Mr. Herbert says:—

"It would be idle for me to speak of his vast intellectual powers . . . but I cannot end this cursory and rambling sketch without testifying, and I doubt not all his surviving college friends would concur with me, that he was the most genial, warm-hearted, generous, and affectionate of friends; that his sympathies were with all that was good and true; and that he had a cordial hatred for everything false, or vile, or cruel, or mean, or dishonourable. He was not only great, but preeminently good, and just, and lovable."

Prof. Huxley, speaking of his name, says:—

"They think of him who bore it as a rare combination of genius, industry, and unswerving veracity, who earned his place among the most famous men of the age by sheer native power, in the teeth of a gale of popular prejudice, and uncheered by a sign of favour or appreciation from the official fountains of honour; as one who, in spite of an acute sensitiveness to praise and blame, and notwithstanding provocations which might have excused any outbreak, kept himself clear of all envy, hatred, malice, nor dealt otherwise than fairly and justly with the unfairness and injustice which was showered upon him; while, to the end of his days, he was ready to listen with patience and respect to the most insignificant of reasonable objectors."[1]

It has been somewhat shallowly said—said, in fact, on the day of the centenary of Darwin's birth—that "we are upon very unsafe ground when we speculate upon the manner in which organic evolution has proceeded without knowing in the least what was the variable organic basis from which the whole process started." Such statements show a certain misconception, not confined to the layman, as to the scope and limitations of scientific theories in general, and to the theory of organic evolution in particular. The idea that it is fruitless to speculate about the evolution of species without determining the origin of life is based on an erroneous conception of the true nature of scientific thought and of the methods of scientific procedure. For science the world of natural phenomena is a complex of procedure going on in time, and the sole function of natural science is to construct systematic schemes forming conceptual descriptions of actually observed processes. Of ultimate origins natural science has no knowledge and can give no account. The question whether living matter is continuous or not with what we call non-living matter is certainly one to which an attempted answer falls within the scope of scientific method. If, however, the final answer should be in the affirmative, we should then know that all matter is living; but we should be no nearer to the attainment of a notion of the origin of life. No body of scientific doctrine succeeds in describing in terms of laws of succession more than some limited set of stages of a natural process; the whole process—if, indeed, it can be regarded as a whole—must for ever be beyond the reach of scientific grasp. The earliest stage to which science has succeeded in tracing back any part of a sequence of phenomena constitutes a new problem for science, and that without end. There is always an earlier stage, and to an earliest we can never attain. The questions of origins concern the theologian, the metaphysician, perhaps the poet. The fact that Darwin did not concern himself with questions as to the origin of life nor with the apparent discontinuity between living and non-living matter in no way diminishes the value of his work. The broad, philosophic mind of the great master of inductive method saw too fully the nature of the task he had set before him to hamper himself with irrelevant views as to origins.

No well-instructed person imagines that Darwin spoke either the first or the last word about organic evolution. His ideas as to the precise mode of evolution may be, and are being, modified as time goes on. This is the fate of all scientific theories; none are stationary, none are final. The development of science is a continuous process of evolution, like the world of phenomena itself. It has, however, some few landmarks which stand out exceptional and prominent. None of these is greater or will be more enduring in the history of thought than the one associated with the name of Charles Darwin.

I cannot, indeed, attempt to weigh or estimate the influence and the far-reaching import of the work which all the world has been weighing and estimating during this year, the centenary of his birth and the jubilee of the "Origin of Species." I cannot, to my intense regret, give you any personal recollections of Darwin, for though I think I once saw him in the streets of Cambridge, I have to my sorrow never been absolutely sure that this was so.

But in reading his writings and his son's most admirable Life, one attains a very vivid impression of the man. One of his dominant characteristics was simplicity—simplicity and directness. In his style he was terse, but he managed to write so that even the most abstruse problems became clear to the public. The fascination of the story he had to tell was enhanced by the direct way he told it.

One more characteristic. Darwin's views excited at the time intense opposition and in many quarters intense hatred. They were criticised from every point of view, and seldom has a writer been more violently attacked and abused. Now what seemed to me so wonderful in Darwin was that—at any rate so far as we can know—he took both criticism and abuse with mild serenity. What he wanted to do was to find the truth, and he carefully considered any criticism, and if it helped him to his goal he thanked the critic and used his new facts. He never wasted time in replying to those who fulminated against him; he passed them by and went on with his search.

In the development of the theories associated with Darwin's work the New World played a prominent part. Darwin's "Wanderjahre" were spent on this side of the Atlantic. The central doctrine of evolution through natural selection was forced upon his mind by the studies and researches he made in South America during the voyage of the *Beagle*. The numerous observations in all departments of natural science and the varied forms of life he came across in this classical journey were the bricks with which he built many of his later theories. The storm of controversy which the "Origin of Species" awoke was at least as violent in America as in Great Britain, and we must not forget the parts played by men like Hyatt, Fiske, Osborn, and many others, and above all by Asa Gray and by Brooks of Baltimore, whose recent death has robbed America of perhaps her greatest Darwinian.

It is a somewhat remarkable fact that whilst the works of Darwin stimulated an immense amount of research in biology, this research did not at first take the line he himself had traced. With some exception the leading zoological work of the end of the last century took the form of embryology, morphology, and palæontology, and such subjects as cell-lineage, "Entwickelungsmechanik"; the minute structure of protoplasm, life-histories, teratology, have occupied the minds of those who interest themselves in the problems of life. Along all these lines of research man has been seeking for the solution of that secret of nature which at the bottom of his heart he knows he will never find, and yet the pursuit of which is his one abiding interest. Had Frank Balfour lived we should, I think, have sooner returned to the broader lines of research as practised by Darwin, for it was his intention to turn himself to the physiology—using the term in its widest sense—of the lower animals. Towards the end of the nineteenth century, stimulated by Galton Weldon began those series of measurements and observations which have culminated in the establishment, under the guidance of his friend and fellow-worker, Karl Pearson, of a great school of eugenics and statistics in London. With the beginning of the twentieth century came the re-discovery of Mendel's facts, and with that an immediate and enormous outburst of enthusiasm and of work. Mendel has placed a new instrument in the hand of the breeder, an instrument which, when he has learnt to use it, will give him a power over all domesticated animals and cultivated crops undreamt of before. We are getting a new insight into the working of heredity, and we are acquiring a new conception of the individual. The few years which have elapsed since men's attention was re-directed to the principles first enunciated by the Abbot of Brünn have seen a great school of genetics arise at Cambridge under the stimulating energy of Bateson, and an immense amount of work has also been done in France, Holland, Austria, and especially in the United States. As the work has advanced, new ideas have arisen and earlier formed ones have had to be abandoned; this must be so with every advancing science; but it has now become clear that mutations occur and exist especially in cultivated species, and that they breed true seems now to be established. In wild species also they undoubtedly occur, but whether they are so common (in uncultivated species) remains to be seen. If they are not, in my opinion a most profitable line of research would be to endeavour to determine what factor exists in cultivation which stimulates mutation.

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[1] "Life and Letters of Charles Darwin," vol. ii., 1887, p. 179.

To what extent Darwin's writings would have been modified had Mendel's work come into his hands we can never know. He carefully considered the question of mutation, or, as they called it then, saltation, and as time went on he attached less and less importance to these variations as factors in the origin of species. Ray Lankester has recently reminded us that Darwin's disciple and expounder, Huxley, "clung to a little heresy of his own as to the occurrence of evolution by saltatory variation," and there must have been frequent and prolonged discussion on the point. That "little heresy" has now become the orthodoxy of a number of eager and thoughtful workers who are at times rather aggressive in their attacks on the supporters of the old creed. "That mutations occur and exist is obvious to everyone, but that they are of frequent occurrence under purely natural conditions is," Sir William Thiselton-Dyer thinks, "unsupported by evidence." The delicate adjustment between an organism and its natural surroundings suggests that sudden change of a marked kind would lead to the extinction of the mutating individual. So far as I can understand the matter in dispute, Darwin and his followers held that evolution had proceeded by small steps, for which we may accept de Vries's term fluctuations; whilst the Mutationists hold that it has advanced by large ones, or mutations. But it is acknowledged that mutations are not all of the same magnitude, some, *e.g.* albinism, brachydactyly in man, dwarf habit or glabrousness in plants, may be large; others, *e.g.* certain differences in shade of colour or in size, are insignificant, and indeed Punnett has suggested that under the head of fluctuating variation we are dealing with two distinct phenomena. He holds that "some of the so-called fluctuations are in reality mutations, whilst others are due to environmental influence." He thinks the evidence that these latter are transmitted is slender, and later states that "Evolution takes place through the action of selection on these mutations. Where there are no mutations there can be no evolution." The disagreement about the way in which evolution has proceeded has perhaps arisen from a misunderstanding as to the nature of the two kinds of variation described respectively as mutations and fluctuations. Mutations are variations arising in the germ-cells and due to causes of which we are wholly ignorant; fluctuations are variations arising in the body or "soma" owing to the action of external conditions. The former are undoubtedly inherited, the latter are very probably not. But since mutations (using the word in this sense) may be small and may *appear* similar in character to fluctuations, it is not always possible to separate the two things by inspection alone. The whole matter is well illustrated by the work of Johannsen on beans. He found that while the beans borne by any one plant vary largely in size, yet if a large and a small bean from the same plant are sown, the mean size and variability of the beans on the plants so produced will be the same. The differences in size are presumably due to differences of condition, and are not inherited. But if two beans are sown, one from a plant with beans of large average size, and one from a bean of small average size, the bean plant the parent of which had the high average will bear larger beans than the one from the parent with small average beans. The faculty of producing a high or low mean size is congenital, is a mutation in the sense used above, and is inherited. It is no doubt unfortunate that the word mutation has been used in several different senses, for it seems to have led to most regrettable confusion and misunderstanding.

As I have said, in such a year, and in my position, I ought perhaps to have devoted the whole of this address to the more philosophical side of our subject; but, in truth, I am no philosopher, and I can only say, as Mr. Oliver Edwards, "an old fellow-collegian" of Dr. Johnson's, said to the "great lexicographer" when they met after nearly half a century of separation: "I have tried too in my time to be a philosopher, but I don't know how, cheerfulness was always breaking in."

II.

Organising Zoology.

I now turn to a subject of the greatest moment and of the greatest difficulty, and one on which there is little general consensus of opinion. The question I wish to raise is this—are the zoologists of the world setting about their task in an economic and efficient way?

We live surrounded by a disappearing fauna. Species are disappearing from the globe at a greater rate than even the most ardent mutationist claims they are appearing. To mention but a few striking cases: The European beaver has almost gone, though a few linger on around the periphery of the Continent. Norway, the lower Danube, Eastern and Arctic Russia still harbour them, and a very few are said still to inhabit the Rhine and the Rhone. The European bison is now represented by a few wild specimens in the Caucasus. The American bison is reduced, and that by the deliberate and calculated action of man, to a few herds most carefully preserved by Government; the largest of these, containing some 600 heads, is now at the National Park at Wainwright. Equally deliberate and equally calculated is the destruction of the fur-seal, which threatens soon to be complete. The Greenland sealing is almost a thing of the past. In 1860 British vessels killed 68,278 seals; in 1866, 103,578; and this went on until 1895, when the pursuit was abandoned by the British, it being no longer found to pay them, though Norwegians still continue "sealing." In 1859 19 vessels sailing from British ports killed 148 whales; in 1881 12 vessels killed 48 whales; last year 6 Dundee vessels killed but 15, and the year before that but 3. The whalers sailing from Newfoundland ports killed 1275 whales in 1904, 892 in 1905, and only 429 in 1906.

At the present time certain Norwegian whaling companies have been for the last few years actively at work in the Shetlands, and are killing off as fast as they can the common rorqual (*Balaenoptera musculatus*, L.), the lesser rorqual (*B. rostrata*), Sibbald's rorqual (*B. sibbaldi*, Gray), the cachalot (*Physeter macrocephalus*, L.), the humped-back whale (*Megaptera boops*, L.), and, when they can reach him, the Atlantic right whale (*Balaena mysticetus*, L.). These are killed primarily for their blubber, but the economy of the factories rivals that of the Chicago pork-packing industries. Nothing is wasted; the flesh is made into sausages, which are readily eaten in Central Europe, and the bones are ground up to make manure. No animal which produces but few young can withstand such persistent and organised attacks on the part of man, and I fear, before many years are passed, many species of whale will be extinct. At the present moment the two right whales seem almost on the verge of extinction, and *Balaena mysticetus* will probably go before *B. australis.* Nothing shows this more clearly than the price of whalebone, which has gone up in the last eighty-four years from 56*l.* per ton to 2100*l.* per ton, or from 12 cents a pound to 4·90 dollars, and in some years to 5·80 dollars a pound. The number of pounds on sale in the United States has dropped from 2,916,500 in 1851 to 96,600 in 1906. With the whales will disappear the whale-lice and the whole of the very interesting parasitic fauna which inhabit their vast interiors.

The *disappearance of the large* game from enormous tracts of country in Africa is too well known to delay us. The elephant, except where preserved in the Litzikama Forest, near Mossel Bay, and in the Addo Bush, near Port Elizabeth, is exterminated south of the Limpopo. The price of ivory, again, is a measure of the nearness of its extinction. The best pieces, which are used for billiard balls, have risen in price from 55*l.* a cwt. in 1882 to an average of 100*l.* a cwt. in 1908. The common and the *brindled gnu* (*Connochoetes taurinus*) are fated to follow the extinct quagga. The blesbok (*Damaliscus albifrons*), formerly found in thousands in Cape Colony, the Transvaal, and Bechuanaland, is now very rare, and seems doomed. The giraffe has long been driven out from South Africa, though it still roams over large tracts of country in East and Central Africa.

Perhaps the most striking case of the disappearance of a mammalian fauna is that presented in Western Australia. Here many districts are now said to be entirely devoid of indigenous mammals, and this depletion is in the main an affair of only the last thirty years, and many of the local extinct forms are still remembered by the older natives and colonists. Mr. Shortridge, a collector who has worked for some years in South-west and Western Australia, writes in a letter: "The entire disappearance of so many species over such large tracts of country is generally considered to be due to some epidemic perhaps brought into the land by introduced animals. It is to be noted that they have died out chiefly in the dry regions, where, except for the introduction of sheep, there has been very little alteration in the natural conditions. Rabbits, although already very numerous in the Centre and South-east, have not as yet found their way to the North-west." Amongst the mammals which have almost, if not quite, disappeared from West Australia are the banded wallaby (*Lagostrophus fasciatus*), the hare wallaby (*Lagochestes hirsutus*), the rat-kangaroos (*Potorous gilberti* and *P. platyops*). The indigenous rats and mice of Australia are disappearing even faster than the marsupials, and it seems probable that many will not be heard of again.

A very few years ago the ship employed by the company which is exploiting the phosphates of Christmas Island introduced the brown rat (*M. decumanus*) there. Within a short time the two indigenous rats first collected by Mr. C. W. Andrews, of the British Museum, named *Mus macleari* and *Mus novitatis*, were wiped out of existence. The same animal having been introduced in North America is gradually spreading, and as it spreads the native fauna of Muridæ is slowly vanishing.

To adorn our ladies' heads some of the most beautiful of birds are being systematically exterminated. In the London market alone were sold last year some 50,000 sooty terns (*Sterna fuliginosa*, *S. anaestheta*, and *S. bonata*), 20,000 specimens of the crowned pigeon (Goura) from New Guinea, their sole habitat, immense numbers of "osprey" feathers, egret and heron, and more than 50,000 birds of paradise, or more than double the number of the year before.

I have no time to continue this melancholy record, but it could be prolonged almost indefinitely.

When we reflect how greatly we treasure every scrap of knowledge we can glean about such recently extinct animals as the Rhytina—Steller's sea-cow—the dodo, the great auk, we must see that if it be impossible to check the gradual disappearance of those animals doomed to extinction, we should at least monograph them and take every care that what can be permanently kept of their structure should be kept. In respect to the recording of the habits and physical features of a disappearing race, the anthropologists are setting an example which the zoologists would do well to follow.

We are living with a disappearing fauna around us, and numerous as the museums of the world are, and skilled and painstaking as the curators of these museums are, they are both wholly inadequate to deal with the material at hand. Some dozen years ago Dr. Günther made a very careful estimate of the number of species of animals which were known in the years 1830 and 1881. I summarise his table:—

Number of Species known in the years 1830 and 1881.

	1830		1881
Mammalia	1,200		2,300
Aves	3,600		11,000
Reptilia and Batrachia ...	543		3,400
Pisces	3,500		11,000
Mollusca	11,000		33,000
Bryozoa	(40)		120
Crustacea (year 1840) ...	(1,290)		7,500
Arachnida	1,408		8,070
Myriapoda	450		1,300
Insecta	49,100		220,150
Echinodermata (1838) ...	(230)		1,843
Vermes (1838)	(372)		6,070
Cœlenterata (1834)	500		2,200
Porifera (1835)	(50)	*say*	400
Protozoa (1838–44) *say* ...	(305)	,,	3,300
	73,588		311,653

Taking an average year between 1881 and the present date, but rather nearer the latter, because each year the number of newly described species becomes larger, Dr. Sharp tells me that, according to the zoological record, 12,449—let us call it 12,450—new species were described in the year 1897.

Number of new Species described in the year 1897.

Mammalia	285
Aves	105
Reptilia and Batrachia	140
Pisces	148
Mollusca	1,077
Brachiopoda	7
Bryozoa	6
Crustacea	239
Arachnida	659
Myriapoda	275
Insecta	8,364
Echinodermata	491
Vermes	294
Cœlenterata	164
Porifera	95
Protozoa	100
	12,449

This number, however, includes fossils which I do not think were included by Dr. Günther. We might deduct 450 for them if we wish to confine our attention to living animals. This leaves us 12,000. If we multiply this by 27, the number of years which have elapsed since Dr. Günther made his estimate, we find a total of 324,000. This number is possibly too large, as it makes no allowance for synonyms; still, it is a rough indication that since 1881 the number of described species has been doubled. Isolated groups, such as the mammals, treated in the same way, give us fairly similar results, so that now we may, I think, say that there are more than 600,000 described species of living animals.

It thus appears that during the fifty-one years in the middle of the last century the number of known species grew by some 238,000, giving an average increase of a little less than 5000 per annum. At the present day there are far more workers in the field than there were thirty years ago, museums have multiplied, and there are many more zoologists, and it is now estimated that the number of species annually described and named amounts to some 12,000.

The number, large as it seems, is, however, but small in comparison with the number of species collected and deposited in museums where no one has time to work them out. It is still smaller in comparison with the vast numbers of species as yet uncaptured. Dr. Sharp, in 1895, calculated that there were a quarter of a million known and described insects. This was an increase of 30,000 over Günther's figures of fifteen years before, but he states that in his opinion this quarter of a million is but one-tenth of those which exist.

With the exception of the larger Mammalia—though the Okapi warns us the exception may yet prove the rule—there is no group of animals which may not yield us new surprises—no group which we can regard as well worked out, though naturally some are better known than others. What, then, are the zoologists of the world doing to record the animal life around them? One thing of late is certainly an improvement. During last century the great zoological collections were in the main increased and augmented by the chance gifts of hunters and sportsmen, whose chief object in their expeditions was not zoology, but what is termed "sport." Many valuable gifts are still received from such sources, but it is now recognised that we must not in these matters trust to the sportsman alone. The plan of attaching trained naturalists and experts in taxidermy to an expedition avowedly meant for other purposes is good, and is well exemplified by Mr. Roosevelt's "safari" in East Africa at the present time. We may hope that we may never again see an expedition without a single trained naturalist on its staff, such as the last Stanley led across Africa. A still better plan is to send out expeditions of trained naturalists to do definite pieces of work. Such expeditions as Andrews and Foster Cooper and Osborn to the Fayum for fossils, of Cunnington and Boulenger to the same region to investigate the fauna of the lake, or Wollaston and his companions to the Ruwenzori district, yield a harvest one hundred times more abundant than the best of other schemes.

Yet even here I would plead for a little more organisation. One must not suggest too rigid a scheme, and it is to be hoped that in the future, as in the past, there will always be found wealthy men willing to devote their energies to the advancement of zoology. Such work has been done by Mr. Godman on the fauna of Central America. one of the richest regions in the world, and now, owing to his munificence, one of the best known. The stately array of volumes embodying these results is paralleled by the magnificent monographs in which the results of the Prince of Monaco's marine researches are recorded, and by the monographs of the Princeton Expedition to the Argentine, financed by one of the richest of the millionaires of the United States. We trust that such enterprises will always continue.

With regard, however, to expeditions financed from public funds which are sent out officially, it might be possible to have more international cooperation. Just as the members of the Geodetic Survey meet from time to time and determine the next step to be taken in the triangulation of the world, so it seems to me might the members of the chief museums of the world meet, say, triennially, and draw up certain thought-out plans for the exploration of the zoological world.

With regard to working out the material when collected, the existing museums of the world are too few, and their staffs are too small to deal, not only with the huge collections which are constantly pouring into their buildings, but even with the accumulated stores already housed there. In our smaller State museums it is not uncommon to find men who are responsible for the whole of the Arthropoda. Only within the last few months I have had to try to find for a Metropolitan museum a curator who was expected to be a specialist in fishes, molluscs, and arachnids. Now is it possible to expect such men, able and zealous as they are, accurately to determine species in these vast and complex groups? My own feeling is—but I fear I shall carry no one with me—that we must specialise still further. I should like to see each of the great classes of the animal kingdom assigned to one of the great museums of the world. Just as an example—which is only an example, possibly a bad one—I suggest that all the type-specimens of Amphibia be sent to one museum, say, if you like, that of Berlin or St. Petersburg; in return for this that museum should distribute to others its types of fish, birds, &c. Then, at this museum there would arise a series of specialists capable of deciding swiftly and accurately on the validity of the claims of any new species of amphibian that may be advanced. Again, a student of Amphibia, instead of wandering round the museums of the world if he wishes to study species, would find all he wants within the four walls of one building. When once the type is described and deposited, it would be the duty of the museum to distribute co-types and accurately named specimens of the same species to other museums in some recognised order. Smaller groups might be allocated to smaller museums, *e.g.* the fleas to Tring and the ticks to Cambridge—at both these places there are now specialists working out world collections of these pests. What I want is a world's Clearing House for animals. I know I shall be told that my suggestions can never be realised, that international jealousies would prevent such a scheme being adopted, that I am proposing to fetter research. I admit the difficulties, but do not regard them as insuperable. When you recall the international Clearing Houses for the Postal and Telegraphic service, for the banking of the world, and when we reflect what private enterprise does, under the name of Lloyd's, for the shipping of the world, how it registers and describes and certifies, with a minuteness not surpassed by any maker of species, each ship in the world; how, through its signal stations and by other means, it follows the daily course of each vessel, so that at any hour of any day it can state where, in normal circumstances, that vessel is, it does not seem to me impossible to come to some understanding as to dealing with the animals of the world. Only by some such means can we hope to cope with the problem before us.

One other fruitful source of "waste of time" I will mention. That is the debatable matter of zoological nomenclature, more especially the questions of synonymy. The British Association at their last meeting passed a resolution on the proposal of Mr. G. A. Boulenger in the following sense:—

"The undersigned zoologists, whilst fully realising the justice and utility of the rule of priority in the choice of scientific names for animals, as first laid down by a committee of the British Association in 1842, wish to protest against the abuse to which it has been put as a result of the most recent codes of nomenclature, and consider that names which have had currency for a great number of years should, unless preoccupied, be retained in the sense in which they have been universally used. Considering the confusion that must result from the strict application of the rule of priority, they would welcome action leading to the adoption of a scheme by which such names as have received the sanction of general usage, and have been invariably employed by the masters of zoology in the past century, would be scheduled as unremovable."

Mr. G. A. Boulenger expressed disapproval of the extreme application of the rule of priority in zoological nomenclature on the ground that it had already produced much mischief under the pretence of arriving at ultimate uniformity. The worst feature of the abuse of this rule is not so much the bestowal of unknown names on well-known animals as the transfer of names from one to another, as in the case of Astacus, Torpedo, Holothuria, Simia, Cynocephalus, &c., so that the names which were uniformly used by Cuvier, Johannes Müller, Owen, Agassiz, Darwin, Huxley, and Gegenbaur would no longer convey any meaning; very often they would be misunderstood, and the very object for which Latin or Latinised names were introduced would be defeated.

The International Congress of Zoology takes, I believe, a somewhat sterner view, but they are engaged in drawing up a list of names which they hope will be accepted for all time. I for one am prepared to accept them, and I am prepared to go further. I would ask the International Congress if, instead of drawing up a list of single species, or perhaps in addition to it, they would draw up a list of systematic monographs, the names in which may be regarded as final. After all, modern classification began with a book, and it would take no longer, or very little longer, to sanctify a book which may contain diagnoses of hundreds of species than to sanctify the single species. The idea is due to Mr. Cyril Crossland, and he suggests—he was working at Chætopods—that such works as Claparède's "Annelides Polychètes du Golfe de Naples," Ehler's "Die Borstenwürmer," McIntosh's "Monograph of the British Annelids" be accepted. Possibly whole categories of books might be considered, such as the "*Challenger* Reports," and especially "Das Tierreich," the admirable volumes of which we owe to the enterprise of the Berlin Zoological Society. Such a scheme would certainly cause some minor injustices, but every scheme does that. The immense advantage of allowing a researcher readily to determine and give an accepted name to an animal he is investigating without waiting weary days in struggling through a vast and scattered literature for the sake of synonymy would surely far out-balance any temporary injustice.

One last phase of my subject and I have finished with what I want to say on the subject of organising zoology. In Europe the great museums of our metropolitan towns are State museums, endowed by the State, managed by the State, and in Great Britain and Ireland staffed and curated by the State; that is to say, the officials at the museums are Civil Servants. Let us consider for a moment what that means, and let us take the British Museum, which, in its entirety, is second to none in the world as an example of a State museum.

The British Museum was established by an Act of Parliament in the year 1753 (26 Geo. II. cap. xxii). This Act sanctioned the purchase of collections and library of Sir Hans Sloane, that prince of collectors, for the comparatively insignificant sum of 20,000*l*. In fact, Sir Hans left his magnificent collection of natural objects, which, twenty years before his death, amounted to just under 70,000 specimens, his library of 40,000 printed volumes and 4100 manuscripts, to the nation, on condition that 20,000*l*., about one-fourth of the estimated value of the collections, be paid to his executors. Under the above-mentioned Act 10,000*l*. were paid to each of Sir Hans Sloane's daughters, Mrs. Stanley and Lady Cadogan. The same Act provided 10,000*l*. for the purchase from the Duchess of Portland, heiress of the second Earl of Oxford, of the Harley collection of charters and manuscripts, which were then in the market, and other moneys for the purchase and repair of Montagu House, Bloomsbury, and for maintenance. The Act incorporated with the Museum the Cottonian Library at Westminster, which, by an Act of Parliament of William III.'s reign, was under the care of trustees, chief amongst whom were the Archbishop of Canterbury, the Lord Chancellor, and the Speaker; the money was raised by a lottery, and the museum was opened in January, 1759, just 150 years ago.

Now it will be noticed that at its formal birth the museum consisted of about two equal parts—on the one hand books and manuscripts, and on the other what used to be called "natural objects."

The "General Repository," as the Act of George II. called it, was placed in the hands of a body of trustees, now forty-nine in number, three of them relics of William III.—namely, the Archbishop of Canterbury, the Lord Chancellor, and the Speaker of the House of Commons, are trustees by virtue of office. These three are known as the principal trustees; there are twenty-one other trustees in virtue of their office—*e.g.* the Bishop of London, the Presidents of the Royal Society and Royal Academy, and so on—one is appointed by the Crown, nine represent the families of donors, and fifteen are co-opted. So large and unwieldy a body cannot, as a whole, transact the business of a great museum, and they have largely delegated their functions to a standing committee of the three principal trustees and fifteen annually appointed representatives.

Now the manner of appointing to the museum is this. The junior members of the staff are selected as the result of examination, and when appointed they become Civil Servants. Not a bad thing in itself, but bad for a man of science. He, through no fault of his own, becomes entangled in red tape; above all, he must not make himself a nuisance; *trop de zèle* must be avoided, his enthusiasms tend to become checked, he is perpetually observing what is called "official reticence," and he perforce spends his days in performing routine work during routine hours. No amount of skill and ability—and the staff at the museum is both skilled and able—hastens his promotion. This is a matter almost entirely of seniority. In fact, the conditions of the Civil Service are incompatible with that freedom to research in any line that proves most suggestive, and with that absence of outside control which alone makes scientific research on a large scale possible.

The appointment to the senior staff, the keepers or heads of departments, the Director of the Natural History Museum, and the chief librarian, are vested in the three chief principal trustees. This takes us back to the reign of William III. and the Cotton Library at Westminster. No doubt the then Archbishop, the then Lord Chancellor, and the then Speaker, both from propinquity and from their abilities and training, were quite the best men who could be found for this position of trust towards this library. Probably the present holders of these exalted positions—positions which they most worthily fill and which give two of them precedence after royalty in all Britain—are most fully endowed with the qualities which fit them to elect the senior staff for the library and for the collections of works of art and of antiquities at Bloomsbury. I doubt if the same eminent qualities enable them to deal equally satisfactorily with the higher posts in the Natural History Museum. If Parliament, or indeed any other body, were framing a scheme for the management of a great museum of science at the present time, I do not think it would occur to anyone that the holders of the exalted offices I have mentioned were specially fitted, either by the knowledge of the pressing scientific needs and problems of the moment or by their intimacy with the men of science of to-day, to be the most competent electoral body to choose keepers in geology, mineralogy, botany, and zoology. And, indeed, the existing arrangement has broken down. I do not know how long before Sir E. Ray Lankester's resignation of the joint posts of Director and Keeper in Zoology, in December, 1907, it became known to the trustees that that resignation was imminent, but I do know that it was talked about and written about months before that date. Yet after the resignation took effect one whole year elapsed before the trustees appointed a Keeper in Zoology; for twelve months there was no head of a department which contains collections unrivalled in the world. It took the trustees about six months longer to find a Director, and for about eighteen months the charge of this great museum of natural history was vested, under the trustees, in the Chief Librarian at Bloomsbury.

As Prof. Ronald Ross could testify, after scientific research has placed it within the power of man to exterminate so deadly a disease as malaria, the real fight begins; and the real fight is to persuade the authorities to adopt and enforce the measures which are offered them gratis. There is a case in point, if I am not misinformed, on this continent at the present time. It has been known since the time of the making of the St. Gothard Tunnel that lasting and often fatal disease is caused by a small intestinal worm, known as the tunnel-worm or hook-worm. Within the last few years Dr. Wardell Stiles has shown quite clearly that the unhappy condition of "poor white" of the Southern United States is due largely to their being affected by this hook-worm. Their bodies and their intellects are arrested in their development, and the adults amongst them are unable to understand the prophylactic measures he advocates, but the children could be taught if the proper organisation existed for teaching them. Many of the Southern States are friendly to the movement, and I know of no greater service that the central Government of the United States could confer upon the inhabitants of these southern States, in which, as is well known, President Taft takes the deepest interest, than that of detailing Dr. Stiles for several months a year to organise and control this movement. If this could be done, I believe—and I am here speaking of those things that I do know—the United States Government would confer on their own people a benefit as great as they conferred on other nations when they freed Havana of yellow fever and Panama of malaria.

In concluding this part of my address I wish to say as emphatically as I can that if science is to take its proper place in the polity of the nation we must endeavour to have men of scientific training, or at least of scientific sympathies, in the Government and also in the Government offices.

I cannot recollect the name of one single Minister trained in natural or physical science amongst the numerous members of His Majesty's Governments of the last thirty-five years. It is not so very long ago—I am glad to say that one of the actors of my little story is still with us—that Sir Joseph Hooker, then Director of the Royal Gardens at Kew was walking through the grounds with Mr. Ayrton, President of the Board of Works, which in those days was the Government Department responsible for Kew.

They happened to run across Mr. Bentham, the great authority upon the classification of plants. Sir Joseph introduced him to the President, adding, "he works in our herbarium." "Dear me," said the President, "I hope you don't get your feet wet." Now I do not want for a moment to suggest that our present genial President of the Board of Works—whose official connection with Kew has been long severed—would not readily distinguish between an herbarium and an aquarium, but what I do wish to emphasise is that this ignorance of some of the most elementary details of scientific method exists in many of our rulers and in many of our permanent officials—not in all by any means; I know of some most notable exceptions—but in many. It is but human to distrust what we cannot understand, and it is this lack of understanding which is largely retarding progress at the present day.

III.

International Ocean Research.

As an example of international cooperation in scientific research I may take the investigations which have been going on for the last seven years in the Baltic Sea, in the North Sea, and in that greater Norwegian Sea which stretches from the western coast of Norway north to Spitsbergen and westward beyond Iceland and the Færöes. In this inquiry no fewer than ten nations—in fact, all those the shores of which touch these seas—have had a share—England, Scotland, Norway, Sweden, Finland, Russia, Germany, Denmark, Holland, and Belgium—and since most of these countries have a special steamer equipped for research and under the command of men trained in scientific methods, it has been possible to collect a mass of facts connected with the seas of Northern Europe such as has never been got together before for any similar area of the ocean.

The aim of those responsible for the scheme of work was to obtain as complete a survey as possible of the physical and biological conditions of the seas in question. They wanted to know the direction of ocean currents, both superficial and along the bottom; the variations in the degree of salinity of the water in time and in space; the nature of the sea-bottom, and whether this could be correlated with the fauna, sessile or moving, found upon it, and whether this fauna reacted on the prevalence or absence of food-fishes; the influence of depth, salinity, and temperature on the fauna; the seasonal variations and fluctuations of the small floating organisms often called the plankton; the life-history of our food-fishes, where and when they deposited their ova; what became of the ova; the distribution of the larval stages; the age at which the fish become mature, and their average length of life.

Then, again, it was hoped that much could be learned about the influence of man's activity on the sea. The relative depletion of the fish population caused by different modes of fishing; the intensity of trawling; how often does the trawl pass over the same ground in a given time? The question whether or no the seas are being over-fished, and, if so, what measures can be taken to lessen this evil, either by close time, limiting the size of fish captured, or by artificial fish-breeding. Many of these last-named problems concern the legislator as much as the man of science. The function of the latter is to provide facts upon which the administrator may act.

Such a vast task as was set out by the International Council in 1902 has necessitated an immense organisation. Some eight or ten steamers are employed making periodic voyages, under the direction of trained men of science. Enormous numbers of temperature-readings, investigations into the speed and direction of currents, and chemical analyses of sea-water have been recorded, and thousands of samples of the bottom, of the animals and plants living thereon, of fish in all stages, millions of fish ova, have been collected and accurately determined. To work up such an amount of material has occupied the attention of a large number of naturalists. Each country has at least one large laboratory devoted to this work, and their results are coordinated and generalised by the central bureau. The English part of the work was entrusted by the Lords of the Treasury to the Marine Biological Association, and has been carried out under the direction of Dr. E. J. Allen and Prof. Walter Garstang at our laboratories at Plymouth and Lowestoft.

Although all the ten countries are working upon what is, broadly speaking, a common plan, each has had its own special problems. In addition to carrying out the broad outlines of an international scheme, they have specialised along lines indicated by their own needs, and have attacked problems the solution of which affected their own special food supply. Thus Norway, where the old open fishing-boat is being replaced by the modern, decked trawler, has especially studied the cod and the saithe, the haddock and the herring, and has devoted much time and labour to the discovery of new fishing grounds, and has successfully done this along the Norse coast, in the Arctic circle, and on the banks between the Færöe Islands and Iceland. They have further established a trade in *Pandalus borealis*, allied to the prawns, which are taken in the deep waters off Norway, and are now to be bought in most fishmongers' shops in Great Britain.

In a similar way the Danes have tracked the eels as they leave the estuaries of the great rivers of Central Europe across the North Sea to the deep Atlantic off the West of Ireland, just beyond the 1000-fathom line. In these depths they spawn, and the resulting larval form, the Leptocephalus, long thought to be a separate genus, lives there for a while, until, gradually changing into an elver, it retraces by some mysterious instinct its parents' path across the ocean and regains the fresh-water rivers which those parents had left.

The English share of the investigation is limited to that part of the North Sea which lies south of the latitude of Berwick, and for the most part to the western half of these seas and to the English Channel; the latter, as we shall see, is a very important area. The work, so far as it has been specialised, deals, in the North Sea, largely with the plaice, with the food of fishes generally, and with the character of the deposits forming the sea-floor, with the creatures growing thereon. In the Channel the English worker is entirely responsible for the study of the hydrography of the water, which, entering the North Sea through the Straits of Dover, contributes greatly to its mass.

As a result of Prof. Garstang's investigations, an important spawning ground of the plaice has been located in the southern bight of the North Sea; the migration of both sexes has been traced to these grounds on the advent of the spawning season, and their return to their feeding grounds in the spring has been followed. During the spawning season it is usual to catch more males than females on the spawning grounds, possibly because at this time the female is inert and elusive, whilst the male is unusually active.

The course of the ova has been traced, chiefly by the Dutch investigators, as they drift towards the shallow fringe of coastal water, by far the greater number along the continental coast. Here the young fry grow up, and after attaining a certain size they leave the shallow coastal waters for the deeper seas off shore. Comparatively few of these, however, reach the feeding ground of the Dogger Bank, and Garstang has been able to show that by carrying the young plaice in steamers and transplanting them at the proper time on to this rich feeding ground, their rate of growth can be greatly accelerated and thus their market value largely increased, just as Dr. Petersen has done in the case of plaice on Thisted Bredning.

A few years ago there was no trustworthy method of determining the age of fish. Petersen's method of arranging the measurements of a large number of specimens in a scale according to size, when they resolved themselves into certain groups, which were considered to coincide with age-classes, has been superseded by the discovery of Reibisch, Heincke, and others, that many of the bones, the scales, and the otoliths of fishes show annual age-rings, like those found in the trunk of a tree or in the horns of cattle. By laboriously counting the rings on the otoliths of thousands of plaice, Dr. Wallace and others have been able to determine their rate of growth, and to show that some specimens attain the age of twenty-five and even twenty-nine years. Similar investigations have shown that the sexes have a different rate of growth. The age at maturity is found to differ in different regions, but in the majority of cases Wallace found that the males are sexually mature (four to five years) a year before the female is capable of spawning (five to six years). We can now correlate age with size and with weight.

The migrations of the plaice and of other fish and their rate of growth depend, amongst many other factors, upon their food supply. And the nature of the food of fishes has recently been re-investigated in the North Sea. I give some of Todd's results, which were made by the examination of some thousands of fish of thirty-one species. Of these I select three—the cod, the plaice, and the dab.

Percentages of stomachs containing various kinds of food.

Cod.

Size of fish in cm.	0–15	15–30	30–60	60+
Pisces ...	0 p.c.	11 p.c.	52 p.c.	67 p.c.
Mollusca ...	0	2	16	4
Crustacea ...	100	95	67	63
Polychæta ...	0	9	9	26

Plaice.

Size of fish in cm.	0–10	10–20	20–30	30+
Pisces ...	0 p.c.	1 p.c.	5 p.c.	5 p.c.
Mollusca ...	17	66	76	84
Crustacea ...	57	16	13	11
Polychæta ...	38	37	51	42
Echinoderma.	0	20	13	6

Dabs.

Size of fish in cm.	0–10	10–20	20–30	30+
Cœlenterata..	0 p.c.	18 p.c.	18 p.c.	20 p.c.
Echinoderma.	0	26	25	2
Polychæta ...	30	22	20	10
Crustacea ...	70	30	35	61
Mollusca ...	2	48	57	65

These tables show what, of course, was more or less known before, that as a rule the young fry live very largely, and in many cases solely, on crustacea. To a great extent the supply of suitable food dominates the movement of the young fry, for nowhere is the truth of the Frenchman's definition of life, "I eat, thou eatest, he eats," with its terrible correlative, "I am eaten, thou art eaten, he is eaten," more true than in the sea. Later in life the fishes' taste alters, and with increased size they can tackle animals the calcareous deposits of which would seem to render them highly indigestible.

Very careful investigations have been made, and are being made, by Mr. Borley and Mr. Todd as to the distribution of the fauna of the middle and southern parts of the North Sea, and its relation to the depth of water, the varying degree of salinity, and to the texture of the bottom deposits. These results, however, have not been published, but I may go so far as to say that the inquiry shows that within the area investigated the texture of the sea floor has, on the whole, more influence on the distribution of the invertebrates of the bottom fauna than has depth, and that depth in the area in question seems to have more influence than salinity.

With regard to the character of the bottom deposits, it has been found by Mr. Borley that off shore and on the gently shelving continental coast the sea bottom is of a uniform character over wide areas, though on the western side it is more patchy; and it has proved possible to divide the samples taken into some nineteen main types, each characteristic of one or more of the areas into which the region has been split up. Only one or two details of this laborious work can be mentioned. One is that the texture or degree of coarseness of the ground in various parts of the sea is such as to suggest that the distribution of the finer grades of material, the finer sands and silts, is greatly influenced by the joint action of currents and tides. It is, for instance, known that in the southern part of the North Sea the main direction of the bottom current is to the north and then to the east; and examination of the deposits shows a regular diminution in the proportion of the coarser sands, a regular increase in the proportion of finer material, as we proceed from the Straits of Dover in a north-easterly direction. A remarkable fact in this connection is the complete absence of silt from the sandy bottom west of the mouths of the great rivers Rhine and Maas. There can be no doubt that the presence of broad and shallow stretches of sand on the Continental, but not on the English, side of the North Sea is one of the factors which has determined the distribution of the small plaice, which on the Continental shores are so extraordinarily abundant, and on the English shores are relatively so scarce.

By means of bottles weighted with shot, so as to have about the same specific gravity as the surrounding sea water, Mr. G. P. Bidder has been able to trace slow currents moving over the bottom of the sea. The bottles are closed, and contain a postcard in many languages offering a reward to whosoever returns the postcard, recording the latitude and longitude of the place it was trawled at, to our laboratory at Lowestoft. Attached to the neck of the bottle is a copper wire 1½ feet long. This wire trails along the bottom, the bottle itself floating about 1¼ feet above the level of the ground. Slowly as the bottles are swept along yet the distance they cover is sufficient to sharpen the free end of the wire to a needle point.

By these and by other methods it has been possible to trace the almost imperceptible but steady flow of waters along the bed of the sea. Without doubt these currents influence the distribution of the larval and young forms of all the creatures which live near the bottom, and especially influence the migration of food-fishes in their younger and less active stages, when they are swept helplessly along.

But these bottles have a double lesson to teach us: not only do they enable us to chart the slow streaming of the bottom water, but they give us to some extent a measure of the intensity of trawling in the North Sea. They have been re-fished in really surprising numbers. Commercial trawlers have re-taken them at the rate of 58 per cent. per annum. In one area these bottles cast upon the waters were re-taken, not after many days, but after very few. Out of 390, eighty-five were recovered in six weeks, and fifty out of 270 were trawled in five weeks, representing a local intensity of fishing which, if continued, would give us between 80 per cent. and 90 per cent. of re-captures in a year.

Marked fish which have been liberated and re-captured tell the same story of intensity of fishing.

The intensity of fishing as indicated by the percentage of re-captures within twelve months of liberation is shown by the following table[1] :—

	Percentage	
Off shore	Fish under 25 cm.	Over 25 cm.
Dutch coast...	23·7	20·3
Deep water, Southern Bight ...	13·0	26·6
Leman Ground (liberated April and May)	18·7	17·4
Leman Ground (liberated December) ...	—	21·0
Horn Reef outer ground	33·3	23·0

Obviously, since some fish are known to have been captured but not returned to the laboratory, the method gives a minimum estimate.

By applying the same method to the marking experiments of other countries as well as our own, Garstang[2] gave the percentage recovered within twelve months of liberation of fish more than 25 cm. in length as from 4 per cent. on the Fisher Bank to 56 per cent. in the Skager Rak.

When we reflect on the chances of these marked fish dying or being eaten or losing their labels, it is surely a most remarkable fact, full of significance to the practical man, that in the North Sea marked fish of marketable size are recaptured at the rate of between 20 and 30 per cent. each year, and sometimes at a greater rate. It would seem that each square yard of the fishing grounds is swept by the trawl, not once, but again and again each year.

Mr. Borley has conducted a large series of experiments to determine the vitality of fish after they have been captured by both the beam and the otter-trawl. It was necessary to determine the degree of injury caused by the actual trawling, the raising of the trawl, and the subsequent exposure on deck. The larger fish of both sexes were capable of resisting the damage to a greater extent than those of smaller size, and the relative resistance of the two sexes varied at different sizes, the male showing a decline in the increase of its vigour as it approaches maturity. One factor which is very deleterious to the fish is the presence of jellyfish in the trawl; these either smother the fish or possibly sting them to death; at any rate, the mortality of the fish is enormously increased when medusæ are present in any numbers. The otter-trawl is also far more harmful than the beam-trawl, and exposure on deck to a hot sun is another constant source of death, one hour's such exposure in one series of experiments killing 99 per cent. of the smaller fish. In the ordinary commercial operation of trawling, whilst the fish are being sorted those that have no market value lie about on the deck of the vessel for at least an average period of one hour; hence it is extremely probable that when shovelled overboard practically all are dead or dying.

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[1] Garstang, "North Sea Fisheries Investigation Committee Southern Area," Report No. 1

[2] "Provisional Report on the Natural History of the Plaice" (Committee B). *Procès verbaux*, vol. iii.

The work which has been done by our own special steamer has been supplemented by records carefully kept by certain selected captains of commercial trawlers, which sail from Grimsby or from Lowestoft. In this way the details of some 20,000 hauls have been examined, and their results tabulated by Miss Lee.

I have left myself no time to describe the important hydrographical investigations carried on by Mr. Mathews into salinity, temperature, &c., which show us the conflicting currents at the mouth of the English Channel and how the North Sea in its southern part is supplied with water from the Atlantic through the Channel. The curious ebb and flow of the Gulf Stream, its periodic welling up and subsidence, closely connected as they seem to be with the migrations of the herring, cod, and haddock shoals, is another most important matter of investigation.

Neither can I tell you in detail of the immense amount of work which is being done by the other countries which share in the international scheme, by the Scottish Fishery Board, the pioneer in Great Britain of this sort of research. To the west our Channel work is beginning to get into touch with the more recently established Irish Fishery Board, and with the work carried on under the direction of Prof. Herdman in the Irish seas.

The outcome of all this minute and continuous investigation will, in time, tell us whether or no the North Sea fisheries are being exploited in the most profitable way—a very important question for our country, for with a fishing fleet of 27,000 vessels, manned by 90,000 fishermen, who land 900,000 tons of fish a year, valued at 10,000,000*l.*, Great Britain takes 90 per cent. of what is caught in the North Sea. Some statistics indicate that there is a falling off. The steam trawlers in 1905 landed 25,000 tons of fish less than in 1904, and in 1904 there was a similar shortage on the total of 1903. And yet 1903 was a year in which some crisis took place; the growth of the haddocks and the number of young haddocks were far less than normal, the Norwegian cod fisheries sank to a minimum, the French statistics showed the same feature in their fisheries off Iceland. In 1903, however, there were unusually large numbers of small plaice. The polar ice-field pressed down south, and seals, cetacea, and arctic birds left their usual quarters, and came south in some cases so far as Shetland. The gigantic climatic changes indicated by the above undoubtedly disturbed for a time the rate of increase and the rate of growth of the fish population of the North Sea, but they soon returned to their normal state. Compared with such mighty influences the fishing activity of man seems almost negligible, and Dr. Hjort for one thinks that "the productiveness of fish" "may be regarded as independent of the interference or fisheries of man." I am not sure that this is so. Taking large areas and all fish into consideration, it may be true; especially it would seem to be so of some species, such as the herring, the saithe, and the cod; but in certain areas and with certain fish, such as the sole and the plaice, man's activity has undoubtedly decreased the number.

Although the researches of the last few years have immensely increased our knowledge of what is going on in the sea, they have, like an ever-widening circle, but increased the number of problems which await solution. It is earnestly to be hoped that the work may go on on at least its present basis. The business man, always on the outlook for a dividend, has sometimes complained that some of our inquiries do not seem to him practical, but he must have patience and faith. A few years ago no knowledge could seem so useless to the practical man, no research more futile than that which sought to distinguish between one species of a gnat or tick and another; yet to-day we know that this knowledge has rendered it possible to open up Africa and to cut the Panama Canal.

And here, if I may quote the words of the author of the Maccabees:

"And here will I make an end."

"And if I have done well, as is fitting the story, it is that which I desired; and if slenderly and meanly, it is that which I could attain unto. . . . And as wine mingled with water is pleasant and delighteth the taste: even so speech, finely framed, delighteth the ears of them that read the story."

"And here shall be an end."

SECTION E.

GEOGRAPHY.

OPENING ADDRESS BY COLONEL SIR DUNCAN JOHNSTON, K.C.M.G., C.B., R.E., F.R.G.S., F.G.S., PRESIDENT OF THE SECTION.

IT has been usual for Presidents of this Section to make some allusion in their addresses to the principal matters of geographical interest which have occurred during the preceding year, and I propose to follow this custom before proceeding with the rest of my address, which would hardly be complete without some allusion to the great geographical achievements of the past year.

I doubt if there has ever been a year in which more important additions to geographical knowledge have been made than those resulting from the journeys of Dr. Sven Hedin, Dr. Stein and Lieut. Shackleton.

Dr. Sven Hedin's previous explorations had deservedly gained him such a high reputation as an explorer that it seemed almost impossible for him to increase it, yet his recent expedition in Tibet, extending over two years, has enhanced his already great reputation.

Refused permission to enter Tibet from India, he was not to be deterred. Travelling round to Leh and making that place his starting point, he entered Tibet and traversed in various directions a considerable tract, previously unexplored, of that country, making a good reconnaissance survey of the country he passed through.

A large part of his journey was through a bleak and inhospitable region, where he encountered intense cold and very great privations. At one time he went for eighty-three days without meeting a living soul, and the cold and hardships were such that out of ninety-seven ponies and mules with which he started only six came through. Yet in the following year, in the depth of winter, Dr. Sven Hedin again traversed this terrible country. In doing so he ran imminent risk of starvation, as his last sheep was killed a considerable time before he got through to country where he could obtain fresh supplies.

Dr. Sven Hedin's tact and resource were as great as his fortitude and courage. He made friends wherever he went, and, although the Tibetan Government sent orders over and over again that he should be turned back, he succeeded in spending two years in exploring the country, maintaining the most friendly relations with the Government officials and others whom he met. Besides exploring and surveying a large tract of previously unexplored country, he investigated the sources of the Brahmaputra, the Indus, and the Sutlej, and in the course of his journeys he accumulated a mass of geographical and other scientific information.

Next comes Dr. Stein's expedition to Chinese Turkestan, by which he has made a most noteworthy contribution to geographical knowledge and antiquarian research.

Dr. Stein, accompanied by that capable surveyor Rai Ram Singh, who was later on relieved by that equally skilful and energetic surveyor Rai Sahib Lal Singh, travelled from India *viâ* Chitral and Kashgar. He commenced survey work in the eastern part of the Mustagh-ata range, and carried it along the Kun Lun Mountains, skirting the southern side of the Takla Makan Desert and the Lob Nor Desert to Suchou and Kan-chou. He surveyed a large area of the mountainous region lying westward of Kan-chou, then crossing the desert from Anshi to Hami he returned north of the Tarim River, skirting the southern slopes of the Tian Shan range, to Kashgar. During this very long journey Dr. Stein came across the ancient frontier wall, built about the second century B.C. He traced it west of Suchou, until lost in the desert, for some 250 miles, and he made various incursions into and across the desert, making discoveries of the greatest antiquarian interest.

After his return to Kashgar he surveyed the last unexplored portion of the Kun Lun Mountains and the country containing the sources of the Khotan or Yurungkash River, which proved to be flanked on the south by a magnificent range of snowy peaks rising to more than 23,000 feet; thence passing the sources of the Keriya River he skirted the southern slopes of this snowy range and finished by connecting this survey with that to the north of this range. The privations and hardships undergone by Dr. Stein and his party were very great, and, just as he completed his last bit of survey, he was unfortunate enough to get his foot badly frost-bitten, and had to hasten to more civilised parts for medical treatment.

Dr. Stein, during his expedition, displayed all the best qualities of an explorer—enthusiasm, determination, skill, and tact. The modest account he has so far given us of his travels, which gives a mere outline of his work, shows that the geographical as well as the archæological results of his expedition are of the greatest value.

The last completed exploration I propose to mention is Lieut. Shackleton's great journey in the Antarctic Circle, which has raised him to a high position among the gallant explorers of the Polar regions.

Lieut. Shackleton personally arranged and supervised all arrangements for the expedition, his experience in the British Antarctic expedition under Captain Scott standing him in good stead.

Having landed in McMurdo Sound, a party consisting of Lieut. Adams, Prof. David, and others ascended Mount Erebus, which is more than 13,000 feet high, all above snow-level.

Later on Lieut. Shackleton and a sledge-party set off southward, and after an arduous journey succeeded in reaching 88° 33′ south latitude, more than six degrees nearer the Pole than any previous explorer. His party travelled altogether about 1700 miles, including relays, in 126 days, a splendid performance in a rough and difficult country under very trying climatic conditions. Soon after passing 83° 33′ south latitude they lost their last pony, and from this point they had to drag their sledges themselves, although their journey involved the ascent of a plateau 10,000 feet high. They only turned back when their diminishing stock of provisions rendered it imperatively necessary to do so. They were for a considerable time on short rations, and found several times that they had expended their food supplies before reaching their next depôt. Had they missed one of these depôts—no unlikely contingency in such a country—they must have perished by starvation. Altogether the sledge journey was a great feat of pluck and endurance.

Lastly, Lieut. Shackleton's colleague, Prof. David, with others, made a sledge journey to the north-west, reaching the South Magnetic Pole. A good deal of triangulation was carried out, many geological specimens were collected and much scientific information was obtained.

Whether we consider Lieut. Shackleton's skill and energy in organising the expedition, the courage and determination displayed in carrying it out, or the results obtained, his expedition will stand out as one of the greatest of the many great efforts to reach the Poles, and as a British expedition it is one that specially appeals to us.

At first sight it would seem that these great journeys belie the opinion so often expressed of late years that the days of the explorer are numbered, and that in future geographers will have to deal with surveys rather than exploration; but, in fact, these splendid achievements only strengthen this opinion. These explorers have considerably reduced the comparatively small area still unexplored, and other expeditions are helping to diminish the unexplored area.

Among those which are in progress I may mention the following:—Colonel Kozlof's expedition to Mongolia, which has already visited Kuku Nor and which is exploring the upper course of the Huang Ho and other parts of Mongolia. Lieut. Boyd Alexander is exploring in West Africa. The Duke of the Abruzzi is investigating part of the mountainous region across our Indian frontier; Dr. Longstaff is exploring another part of that mountain system; Captain R. E. Peary, U.S.A., and Captain E. Mikkelsen are leading expeditions in different parts of the Arctic regions, and M. Charcot is exploring in the Antarctic Circle. Lastly, an important British expedition will start before long to explore part of the Island of New Guinea, one of the largest still unexplored land areas. There are other expeditions, either in progress or projected, too numerous to mention.

The best modern explorers are not now content with exploration or even with a rough route traverse and an occasional observation for latitude; they either themselves make careful reconnaissance surveys of the country adjoining their route or they are accompanied by trained surveyors, who make such surveys.

Again, every year the area surveyed on correct scientific principles is extended. The interesting address of my predecessor, Major Hills, will have told you what is being done in this way in the British Crown colonies. In the British self-governing colonies and in the colonies and dependencies of other Powers the area of regular survey is being continually extended, and in more remote regions surveys are being carried out by Boundary Commissions or for railways or other purposes. Along with the increasing appreciation of the value of geography which has taken place of late years, there has been an increasing recognition of the need for regular surveys, and it is probable that the next generation will find that not only is no considerable area of the earth's surface unexplored, but that the area not yet surveyed at least geographically, or for which a regular survey has not been projected, is getting limited.

I propose in the rest of my address to deal with the regular survey and mapping of new areas, and to discuss various questions connected therewith; if I am right in believing that large areas will be regularly surveyed in the near future, such questions merit careful consideration. I shall state on these points the practice of some of the great national surveys, because their experience seems the best guide for future work; but I recognise that methods suitable for rich and populous countries, such as Germany, France, or Great Britain, may be too costly for many countries and provinces the survey of which has still to be made, and mention will be made of less expensive methods which are likely to be much in demand in future.

It would be difficult to say anything new on the subject I propose to deal with, and I lay no claim to do so, still less do I wish to dogmatise as to the best methods. When I express opinions I shall also state the practice of some of the principal surveys of the world, and my hearers having weighed the matter can accept my opinions or not according to their judgment. In either case my object will have been attained if careful consideration is given to the points raised.

Maps may be roughly divided into three classes:—

(1) Geographical maps—*i.e.* those on very small scales.

(2) Topographical maps. The dividing line between these and geographical maps is not very clearly defined. For the purpose of this address maps between the scales of 4 miles to the inch and $\frac{1}{25000}$ scale will be considered as topographical.

(3) Cadastral maps—*i.e.* maps on large scales mainly for property purposes.

As the time at my disposal will not admit of my discussing all three classes of maps, and as I have on a previous occasion read a paper to this Association on "Cadastra Surveying," I propose to limit my remarks to topographica surveys and maps.

In most of the older countries topographical surveys have originally been made to meet military needs, and as a rule they are carried out under military supervision

In order that they may be useful in case of war such surveys must have been made before war breaks out. The use, however, of topographical maps is not limited to military purposes; on the contrary, they have invariably proved of great value for civil requirements. In one respect they are more useful for civil than for military purposes, as a state of war occurs rarely, and hence while the maps are only occasionally used in connection with war, they are constantly used in connection with civil administration and with public and private business of all kinds. The topographical maps of the Ordnance Survey, prepared originally solely for military requirements, have proved extremely useful for civil purposes. Directly or indirectly all the numerous maps prepared by the trade in Great Britain for civil use are based on them. I believe the experience of all other countries is similar to that of the Ordnance Survey. In most countries in which land is of any value, a cadastral survey for land transfer purposes is needed, as well as a topographical survey. In some cases indeed, the need for a property survey has first made itself felt; thus in the Transvaal and in the Cape Colony, neither of which yet has a topographical survey, there has for many years been a Government Survey Department for making property surveys. The question arises whether there should be two separate surveys, one for topographical and one for cadastral maps, or whether there should be only one survey, the topographical maps being prepared by reducing the cadastral survey. Incidentally the further question arises whether, if two separate surveys are made, they should be under one head.

In most countries—the Ordnance Survey of the United kingdom being an exception—not only are entirely separate surveys made for these two classes of maps, but these surveys are generally under different departments. In some cases the cadastral surveys are isolated farm surveys, showing little detail except property boundaries. Such surveys would, of course, not answer as a basis for topographical maps. In other cases, however, the cadastral surveys show all necessary detail except ground forms, which can be added by a separate survey. The only cadastral survey, so far as I know, which shows ground forms is the Ordnance Survey, the 6-inch maps of which are contoured.

A difficulty in the way of utilising the cadastral survey for the smaller scale maps arises from the fact that a cadastral survey is, from its large size, much slower than a topographical survey. It is often found advisable to take up the survey of the former somewhat irregularly, while it is important for the proper progress of the latter that it should be taken up regularly and methodically. The Ordnance Survey 1-inch map has, since 1824, not had a separate survey of its own, but has been based on the cadastral survey. Ordnance Survey experience has shown that the delays in completing the topographical map, due to this course, have been much greater than one would have expected, and that there are grave disadvantages in having the scale of survey very much larger than that of the finished map. These objections do not apply, or can be overcome, if the cadastral survey of any locality is completed before the topographical map is taken up. This is a condition not likely to be often fulfilled in the case of future topographical surveys. I advocate therefore that, following the general practice, there should be entirely separate topographical and cadastral surveys. I should advocate this even where it is essential to keep the expense as low as possible. More economy would probably result from the adoption of a fairly small scale for the topographical map, from curtailing the small detail to be shown on it, and from showing on the cadastral maps only such detail as is needed for property purposes, than would result from making one survey do for both classes of maps.

On the other hand I consider that, even when separate surveys are made for the two classes of maps, it is advantageous that both should be made under the same head. The more usual course is, however, to have the two surveys independent, and in some cases local circumstances may make the course I advocate inadvisable.

Triangulation.

The first preliminary to any survey should be a triangulation. It is the most satisfactory course, and the best economy in the long run, to carry out with the greatest accuracy possible the primary triangulation on which the survey is to be based. Such a triangulation will remain good for a very long period. For example, the primary triangulation of the Ordnance Survey was commenced in 1791; while some doubts have been expressed whether it is accurate enough to combine with other more recent work for the purpose of investigating the figure of the earth, no one has questioned that even the earliest part of this triangulation is amply accurate enough for map-making purposes.

On the other hand I do not advocate carrying out a primary triangulation until arrangements have been made for basing a survey on it. In South Africa an excellent and very accurate primary triangulation has been carried out. This triangulation was undertaken largely no doubt for scientific purposes. While answering its purpose in that respect it has so far had no surveys of any great extent based on it. An accurate triangulation is now a much quicker and less expensive operation than it used to be. The introduction of Invar tapes and wires has largely expedited and simplified the accurate measurement of base lines, while the improvements effected in theodolites enable equal or greater accuracy to be obtained with the comparatively small and handy instruments now made than could be got formerly with large and cumbrous instruments, such as the 36-inch theodolites, with which most of the primary triangulation of Great Britain and Ireland was carried out. Unless observations are rendered difficult by numerous buildings, by trees or by a hazy or smoky atmosphere, a good primary triangulation should not now be very expensive. It is usual to base on the primary triangulation a minor triangulation of several orders, the object being to have an accurate framework of trigonometrical points on which to base the survey. If it is important to keep the expense low, the trigonometrical points may be rather far apart, intermediate points being fixed by plane table; but it should be remembered that it is the truest economy to make the best triangulation which funds admit of. In forests or in wooded and rather flat country, where triangulation would be very expensive, lines of traverse made with every possible accuracy, and starting and closing on trigonometrical points, may be used instead of minor triangulation.

Detail Survey.

Provided the detail survey is based on triangulation, it may be made by any recognised method. Plane tabling is now almost universally resorted to, and is probably as cheap and convenient as any other method. The vertical heights of the trigonometrical points will have been fixed by vertical angles with reference to some datum. The height of intermediate points can be fixed by clinometer lines, especially down spurs and valleys, and even by aneroid, and from these heights the contour lines can be sketched in. Altitudes can be more accurately fixed by spirit-levelling, but this is an expensive method not likely to be much used in the case of topographical surveys. It is possible that in exceptional cases photographic surveying may be resorted to with advantage, and undoubtedly photographic methods sometimes enable work to be done which would not otherwise be feasible. The photographic method suggested by Captain F. V. Thompson, R.E., is an advance on previous methods. In Canada, I understand that a good deal of photographic surveying has been done, and presumably the conditions in Canada have been found suitable for this method. It has been little used elsewhere.

Scale of Map.

The next point for consideration is the scale on which the map is to be published, and it is an important one. Speaking generally, the cost increases with the scale, and cost is therefore one of the main determining considerations. The physical and artificial character of the country, the amount of detail it may be decided to show on the map, the method adopted for representing hills and other detail, and the method of reproduction to be used, all affect the question.

Clearness and legibility are among the first essentials of a good map, and it is desirable that the scale should be such that all detail it may be decided to show on the map can be inserted without overcrowding, or conversely, if the scale is fixed, the amount of detail and method of showing it should be such as to avoid the common fault of overcrowding the map.

In populous countries, such as Belgium, France, and Germany, where buildings, roads, railways, &c., are numerous, a larger scale is, *caeteris paribus*, desirable, than in less populous countries.

All important detail such as roads, railways, canals, forests, woods, &c., should appear on the map, as should the more important names, but it is a matter for consideration how far minor detail such as orchards, marshes, rough pasture, state of cultivation, &c., should be inserted on the map, and to what extent the less important names should be omitted.

In hilly country hachures and contours, especially if in black, tend to obscure the detail and names, and the smaller the scale the greater this tendency.

Methods of reproduction will be dealt with later, but I may here say that more detail and names can be shown clearly on a given scale if the map is engraved on copper than if reproduced in any other way. The scales adopted by different countries vary very much—I give below the scales adopted by some of the principal surveys.

$\frac{1}{25000}$ scale—Switzerland (the more populous parts), Prussia, Baden, Saxony, Bavaria, and Würtemberg (these German maps, although called maps of position, are practically topographical).

$\frac{1}{40000}$ scale—Belgium and Denmark.

$\frac{1}{50000}$ scale—France (the new topographical map), Algeria, Tunis, Holland, Japan, Spain, Switzerland (the less populous parts).

$\frac{1}{62500}$ scale—the United States (the more populous parts).

$\frac{1}{63360}$ scale (1 inch to a mile)—Great Britain and Ireland, and Canada.

$\frac{1}{75000}$ scale—the Austrian Empire.

$\frac{1}{80000}$ scale—the old staff map of France.

$\frac{1}{100000}$ scale—the German Empire, Italy, Norway, Portugal, Sweden, and Switzerland (Dufour atlas).

$\frac{1}{125000}$ scale—the United States (the less populous parts).

$\frac{1}{126000}$ scale—Russia.

$\frac{1}{250000}$ scale—the United States (barren districts).

The introduction of cycles, motors, and other rapid means of locomotion has led to a demand for a scale which will show a considerable tract of country on a sheet of moderate size. If the standard map is already on rather a large scale, this demand is best met by publishing a reduction of the standard map. This course is followed by Great Britain and Ireland and by Canada, the 1-inch map of which is reduced to and published on the ½-inch scale; but if only one scale is used a compromise must be arrived at which will meet the reasonable requirements of rapid locomotion, as well as the other essentials of a topographical map.

If I may venture an opinion in a matter in which practice varies so much, it is that for countries using British measures in which, owing to dense population, the detail is close the 1-inch scale ($\frac{1}{63360}$) is a very good one, and that for more open parts the ½-inch scale may with advantage be adopted. For countries using metrical measures I should advocate $\frac{1}{62500}$ and $\frac{1}{125000}$ respectively. These scales do not differ largely from those adopted by most of the principal countries, the majority of which use scales between $\frac{1}{50000}$ and $\frac{1}{100000}$ for fairly close countries.

Where it is important to keep the cost down I should advocate a half-inch to the mile or a $\frac{1}{125000}$ scale. All except the most closely populated country can be shown clearly on such scales provided the maps do not show too many names or too much small detail.

The United States have scales of $\frac{1}{62500}$, $\frac{1}{125000}$, and $\frac{1}{250000}$, the general closeness of detail in any area determining which of these three scales is adopted. This arrangement is a good one, and would be still better if the areas published on the $\frac{1}{62500}$ scale were also reduced to and published on the $\frac{1}{125000}$ scale, and if the whole country were published on the $\frac{1}{250000}$ scale. The principle here advocated of having each scale so far as possible complete for the whole country has been carried out by Great Britain, where the whole country, except some uncultivated areas, is published on the 25-inch ($\frac{1}{2500}$) scale, and the whole country on the 6-inch, the 1-inch, the ½-inch, the ¼-inch, and other smaller scales.

Scale of Field Survey.

It is usual to make the field survey for small scale maps on a larger scale than that on which the map is to be published with the view of securing greater accuracy of detail, but this should not be overdone. If the field survey is on too large a scale it entails needless expense, also when the surveyor is working on too large a scale he is apt not to realise the effect of reduction on his survey, and is likely to survey so much detail as to overcrowd the map, thus increasing the cost of the work and injuring the map.

When the map is reproduced by photographic methods the fair drawing is usually on a larger scale than the finished map, so as to get finer results on reduction; but in this case also, for somewhat similar reasons to those stated above, there are limits to the amount of reduction which can be made with advantage.

In these respects the practice of different countries varies considerably.

In Austria the field survey is on the $\frac{1}{25000}$ scale; this is reduced to and drawn on the $\frac{1}{60000}$ scale, and this drawing is reproduced by heliogravure on the $\frac{1}{75000}$ scale.

In France the field survey is on the $\frac{1}{10000}$ or $\frac{1}{20000}$ scale. The survey is reduced to and drawn on the $\frac{1}{40000}$ scale. In Algeria and Tunis, both field survey and drawing are on the $\frac{1}{40000}$ scale. In all cases the French maps are now reproduced by heliogravure on the $\frac{1}{50000}$ scale from the $\frac{1}{40000}$-scale drawings.

In Germany the field survey is on the $\frac{1}{25000}$ scale. This is reduced to the $\frac{1}{100000}$, on which scale the maps are engraved on copper.

In Great Britain the 1-inch map is based on the 25-inch and 6-inch survey. These were reduced, and a fair drawing was made on the 2-inch scale in a manner suitable for reduction to the 1-inch scale—*i.e.* the detail lettering, &c., were drawn so that when reduced to the 1-inch scale they should be in proper proportion. This drawing was reduced and printed by heliozincography on the 1-inch scale, and from these prints was engraved on copper.

In America the field surveys are on the scales of $\frac{1}{48000}$, $\frac{1}{96000}$, and $\frac{1}{192000}$ for the $\frac{1}{62500}$, the $\frac{1}{125000}$, and the $\frac{1}{250000}$-scale maps respectively. The drawings, on the same scale as the field survey, are reduced by photography and engraved on copper.

I consider that the best results are obtained when the field survey is made on double the scale of the finished map; that if reproduction is to be by engraving the fair drawing should be on the same scale as the finished map; that if, on the other hand, reproduction is to be by photographic methods, the fair drawing should be on the same scale as the survey, *i.e.* double that of the finished map. The reduction I advocate should conduce to accuracy of detail and, if reproduced photographically, to fineness of detail, while it is not so great that the surveyor and draughtsman should be unable to realise the effect of reduction.

Detail.

The need of considering the amount of detail, &c., to be shown is not always sufficiently realised. The way in which detail is to be represented also needs consideration, as on small scale maps much detail has to be represented conventionally.

Railways have to be shown conventionally, and should be so marked that they catch the eye without being too heavy.

Roads also should be clearly marked. Where different classes of roads exist they should be distinctively shown, main roads being more prominent than others. It is important to know what roads are fit for fast wheeled traffic in all weathers, and which are fit only for slow traffic. The exact classification of roads must depend on the conditions obtaining in the country. The most elaborate classification is that shown on the French maps, and next that shown on the maps of Great Britain. Provided that important distinctions are represented, the simpler the classification the better.

Forests, woods, marshes, and in some cases pasture, rough pasture, orchards, vineyards, gardens, &c., are shown by conventional signs. While forests, woods, and marshes should certainly be distinguished on the maps, I incline to the opinion that the state of cultivation is better omitted, and that the less small detail shown the better. Such small detail increases the cost and often overcrowds the map. The German $\frac{1}{100000}$ scale shows much small detail, and although the maps are beautifully and delicately engraved on copper, the detail is rather crowded on some sheets. The French Carte Vicinale is, in my opinion, rather crowded with names.

The most difficult question, and that on which opinions differ most, is the method of representing ground forms. Methods which answer well on steep ground are less satisfactory on gentle slopes, and *vice versâ*, and each method is open to some objection.

Ground forms may be indicated by contours, hill shading in stipple, vertical hachures, horizontal hachures, the layer system, or by a combination of some of these.

Ground forms are represented by contours on the $\frac{1}{25000}$-scale maps of the German States, the Swiss Siegfried Atlas, the maps of the United States, the 1-inch map of Canada, the $\frac{1}{40000}$-scale map of Denmark, and the maps of Japan. Where the slopes are steep the contours give almost the effect of hill-shading. Some of these maps give a very good representation of the ground, the best being those in which the contours are in colour.

Hill features are shown by stipple shading on the French Carte Vicinale and the Ordnance Survey four-mile map. In mountainous country stipple shading gives a good pictorial representation of the ground, but it fails in flatter country, and it is often difficult to tell from it which way slopes run.

The Swiss Dufour Atlas ($\frac{1}{100000}$ scale) is a good example of vertical hachuring, as are some of the German $\frac{1}{100000}$-scale maps. Vertical hachures are also used on the Austrian and Swedish maps, and in conjunction with contours on the maps of several other countries.

Vertical hachures when well executed give an artistic and graphic representation of the hills. In the Swiss and British maps the pictorial effect is enhanced by assuming a light from the left-hand top corner. In steep ground, especially when the hachures are in black, these are apt to obscure detail and names. I think hachures are better when printed in colour, but many will disagree with me on this point.

Horizontal hachuring, while having some advantages, is less effective and is little used.

The system generally known as the layer system has been used in Great Britain by the well-known Scotch firm of J. Bartholomew and Co., has recently been adopted by the Ordnance Survey for its ½-inch maps, and is used in the ½-inch maps of Canada. It consists in indicating by various shades of colour the area lying between certain contours; thus one shade may be given to all ground below the 50-feet contour, another shade to ground between the 50-feet and 100-feet contour, and so on. This system gives a general indication of ground form and enables the contour lines to be followed more easily. Its shades of colour enable the eye to pick out more easily all land lying at about the same level. It is most effective in ground with a small range of vertical height, as the vertical depth of layers can then be small and the distinction in colour between successive layers marked. In hilly ground the depth of the layer must be increased, which means that many ground features are ignored on the map, or the number of layers on the map must be large, in which case the distinction in shade between successive layers will be less marked. This method is popular in Great Britain, and enables those who are not versed in reading contours and hachures to realise something of the nature of the ground forms.

A combination of these methods has been used as follows:—

France on her $\frac{1}{50000}$-scale maps shows ground forms by contour lines and stipple shading. This gives a very fair representation of the ground, but where the contours are very close together the effect of the coloured contours on the stipple is not pleasant. Nor does the stipple always look well when it falls on colour.

The German coloured $\frac{1}{100000}$-scale map, the Italian $\frac{1}{100000}$, and the British 1-inch show both contours and vertical hachures.

The Norwegian $\frac{1}{100000}$-scale map shows the features by contours, vertical hachures and shading.

The new British ½-inch scale map has both contours, layers and stipple shading.

Opinions differ so much on this subject, and there is so much to be said for and against each method, that I will confine myself to the opinion that contours reasonably close together should form the principal feature of any method of representing ground forms; that contours by themselves give a very fair representation of the ground; that vertical hachures, if printed so as not to obscure the detail and names, or stipple shading when there is not too much colour on the maps, increase the pictorial effect and are useful additions to contours; that ground forms should preferably be in colour, and that where hachures or stipple are used as well as contours both should be in the same colour.

The German coloured $\frac{1}{100000}$-scale map (brown hachures and contours), the British 1-inch scale copper-plate printed map (brown hachures and black contours), the British 1-inch coloured map (brown hachures and red contours), and the French $\frac{1}{50000}$-scale (grey stipple and brown contours), all give a good representation of the ground, and there are other maps which might be named almost, if not quite, as good.

Vertical Interval of Contours.

The vertical interval between contours should depend partly on the scale, partly on the steepness of the ground. Practice varies considerably in this matter.

The $\frac{1}{25000}$-scale maps of Switzerland and of Germany, except Prussia, are contoured at 10-metre intervals.

The $\frac{1}{50000}$-scale maps of France are contoured at 10-metre intervals.

The $\frac{1}{50000}$-scale maps of Japan and Spain are contoured at 20-metre intervals.

On the Swiss $\frac{1}{50000}$ scale contours are 30 metres apart.

On the United States $\frac{1}{62500}$ scale the contour interval varies from 20 to 100 feet.

On the British 1-inch map there are contours at 50 feet, at every 100 feet up to 1000 feet, and thence at 250-feet intervals.

On the Canadian 1-inch and ½-inch maps the contour interval is only 25 feet, but the sheets published have been in ground with only moderate elevations.

On the German $\frac{1}{100000}$-scale the contour interval is 50 metres.

I consider that if the contours are printed in colour the vertical interval may with advantage be such that on steep ground the contours are reasonably close together, every fourth or fifth contour being printed heavier so as to be more easily followed. If the contours are in black they cannot with advantage be so close.

It is, in my opinion, best if the contour interval is uniform all over a country. Failing this, it seems desirable that it should be uniform over considerable areas and at least throughout a sheet; but this view is not universally held. I do not like the varying interval adopted by the Ordnance Survey. The contours on the Ordnance Survey maps are surveyed with great accuracy and at great expense. For topographical maps much cheaper and more rapid methods will suffice.

Cartography.

I have, with a view to clearness, kept the question of the method of reproduction separate, but it has a bearing on some of the points already considered. Thus the fine engraving of the German $\frac{1}{100000}$-scale map enables an amount of small detail and ornament to be shown on that map which could not have been clearly shown if any other method of reproduction had been used.

The older maps were generally engraved on copper, or sometimes on stone, and printed in black and white. Subsequently photographic methods, such as the photogravure of the Austrian and the more recent $\frac{1}{50000}$-scale French maps, were used, and colour printing is now largely resorted to.

In some cases the colour-plates are prepared by engraving on copper, stone, or zinc. The maps of the United States and Switzerland are engraved on copper. In other cases, for instance, the 1-inch Ordnance Survey, colour-plates are prepared on stone by transfers and offsets from the engraved copper plate. In other cases—*e.g.* the $\frac{1}{50000}$-scale map of France—the colour-plates are prepared by photographic methods.

For clearness, delicacy of outline, and artistic effect nothing equals engraving on copper. It forms also the best basis for colour-printing. Unfortunately it is very slow and costly.

Engraving on stone is quicker and less expensive than copper engraving. It is inferior in delicacy to the latter, but some of the best stone engraving is very good.

Photographic methods are the most rapid and the cheapest, and with care give very fair results. As good examples I may quote the $\frac{1}{75000}$-scale maps of Austria, prepared by heliogravure, and the 6-inch maps of the Ordnance Survey, prepared by heliozincography, both black and white maps.

Of colour-printed maps I may instance the new $\frac{1}{50000}$-scale map of France prepared by heliogravure, and the ½-inch Ordnance Survey map hitherto prepared by photo-etching, although I understand that in future the outline will be engraved on copper.

When rapid reproduction and moderate cost are desired I do not hesitate to recommend photographic methods which, although not so good as engraving, give, when carefully executed, reasonably good results.

Opinions differ as to the extent to which colour should be used, the modern tendency being to use it very freely. I can hardly be accused of prejudice against colour, as during my tenure of office at the Ordnance Survey colour-printing was largely developed, but I think it is often overdone. I consider that a moderate amount of colour is a great improvement to a map. Ground forms, however indicated, can, in my opinion, be better shown by colour than in black; it is advantageous also to distinguish water by colour, to give prominence to main roads by colouring them, and to colour woods and forests, but I do not advocate going much beyond this. It is difficult to choose colours which are suitable, distinctive, and harmonious, and the more numerous the colours used the greater the difficulty of doing so.

Colour-printing introduces possible sources of error. Colour maps are based on a drawing on which all detail to appear on the map is shown. A plate is prepared for each colour on which there should be only such detail as shall be printed in its particular colour. In preparing this plate there is a risk that detail which should appear may be omitted, or that detail be inserted which should be on another plate, or that the detail may be slightly out of position. Again, owing to change of temperature and to the varying amount of moisture in the air, paper contracts or expands. Registration can rarely be mathematically correct, and with every care may sometimes be appreciably out. While with care errors such as I have indicated can be minimised so as not appreciably to affect the map, it is difficult to ensure that they should be altogether absent.

To recapitulate my views, I advocate for a topographical map a scale between $\frac{1}{62500}$ and $\frac{1}{126720}$ (½ inch to a mile), according to circumstances. The scale of survey to be double that of the finished map; ground forms to be shown by contours reasonably close together, the exact interval depending on the scale of the map and the nature of the country, also, if funds are available, by vertical hachures; both contours and hachures, if shown, to be in colour, the same colour being used for both. If considerations of time and cost do not admit of reproduction by engraving on copper, the map to be reproduced by some photographic method and printed in not more than five colours. I put forward these opinions rather as a basis for consideration than as having special weight in themselves. With the increasing recognition of the importance of geography an increasing demand for maps is sure to come, and good maps can only be satisfactorily designed after considering the points here discussed.

It is not yet, I think, generally recognised that a really good topographical map, based on triangulation, may be produced on a scale of about ½ inch to the mile at very moderate expense if unimportant detail is left out and survey and reproduction carried out as economically as possible. Such a survey has recently been carried out in the Orange River Colony, a country mainly agricultural with generally poor land. There must be few parts, other than barren and mountainous regions, under settled government where such a survey would not be of value. I believe that in future still further economy in surveying and mapping will be attained, and this will stimulate the undertaking of fresh surveys.

Meeting, as we are privileged to do this year, in Canada, I should like to say a few words on the surveying and mapping of the Dominion. Until recently the only maps published have been on very small scales and have shown no ground forms. During the last few years, however, a regular topographical survey has been undertaken by the Militia Department. I am glad that for this topographical survey the scales of 1 inch and ½ inch to the mile, both standard scales in Great Britain and Ireland, have been adopted. They are, in my opinion, suitable scales for Canada, and it is to be hoped that for any new mapping within the British Empire these or similar scales may be adopted as they have been in many parts. Uniformity in scales is very desirable.

Without committing myself to praise in every respect of the maps prepared by the Militia Department, I may say that they appear to me excellent, well-executed maps. Not many sheets have yet been issued, and they are probably not yet well known even in Canada; but I have little doubt that when known their value will be appreciated, and that the area mapped will be rapidly extended. There are no doubt large areas in Canada for which a smaller scale than 1 inch will suffice, but there can be few, except waste and barren regions, for which maps on some scale will not be needed. To a country like Canada, which has made wonderful progress already, and which has a great future before it, adequate mapping must be of importance, specially so in view of the vast area of the country. I have misread the character of the Canadian people if they will be content with any except first-rate maps for the whole settled area of the Dominion.

I should like to have said a few words on the aid which good maps give to geographical education, but my address is already too long. I will only say that while good maps and geographical education are of use to all countries, they are of special value to the British Empire, the different parts of which are geographically so scattered, but which are so closely bound together by common ties of kinship, interest, sentiment, and loyalty.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE issues of the *Lancet* for August 28 and *British Medical Journal* for September 4 are "educational" numbers, and give full information for those desirous of entering the medical profession and of the various services with medical officers attached.

A NEW mathematical professorship has been created, we learn from the *Revue scientifique*, in the University of Paris with the title of the Chair of the Theory of Functions. Prof. E. Borel has been appointed to the new post, which brings the number of mathematical professors in the University up to twelve.

A CIRCULAR from Principal Miers announces that an Appointments Board has been constituted by the University of London. The terms of reference to the Board are "to assist graduates and students of the University in obtaining appointments, and to coordinate and supplement the work done by the schools and institutions of the University with this object." The aim is to encourage the selection of university men for all posts in the work of which the possession of a university training on scientific methods is an advantage. The Board wishes to assist graduates to find employment, and to assist employers to find, in the university ranks, suitable men for vacancies.